Rec'd PCT/PTO 07 FEB 2005

PC[illegible]AU03/00971

REC'D 19 AUG 2003
WIPO PCT

**PRIORITY DOCUMENT**

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

**Patent Office**
**Canberra**

I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2002950972 for a patent by JAMES RICHARD HUNT, GEOFFREY RUSSELL TURNER and ANDREI VADIMOVITCH SHINKARENKO as filed on 23 August 2002.

COMMONWEALTH OF AUSTRALIA
AUSTRALIA
PATENT OFFICE

WITNESS my hand this
Eleventh day of August 2003

JULIE BILLINGSLEY
TEAM LEADER EXAMINATION
SUPPORT AND SALES

BEST AVAILABLE COPY

AUSTRALIA

Patents Act 1990

**PROVISIONAL SPECIFICATION**

**Applicant(s):**

GEOFFREY RUSSELL TURNER

ANDREI VADIMOVITCH SHINKARENKO

JAMES RICHARD HUNT

**Invention Title:**

FUEL DELIVERY SYSTEM

The invention is described in the following statement:

# FUEL DELIVERY SYSTEM

## Field of the Invention

This invention relates to a fuel delivery system and, in particular, to a fuel delivery system for delivering liquid gas such as liquid petroleum gas, together with diesel fuel to a diesel engine.

## Background Art

Our co-pending International Application No. PCT/AU02/00453 discloses a fuel delivery system of the above-mentioned type, which successfully enables a diesel engine to run on both diesel fuel and liquid petroleum gas. The contents of this International application is incorporated into this specification by this reference.

## Summary of the Invention

The object of the present invention is to provide further improvements to the fuel delivery system to further increase fuel economy and also to decrease emissions.

The invention may be said to reside in a fuel delivery system for an engine including:

a liquid injector for receiving liquid gas and for ejecting liquid gas in liquid form to the cylinders of an engine;

means for preventing vaporisation or bubbling of the liquid gas in the liquid injector so the liquid gas is ejected from the injector in liquid form;

collection means for collecting vaporised liquid gas; and

a bleed injector for delivering the collected liquid gas vapour to the cylinder of the engine.

The use of both the liquid injector and the bleed injector to deliver liquid gas in liquid form and liquid gas in vapour form to the engine allows both injectors to be

operated so that the liquid gas is delivered only when the inlet valve of the cylinder is open and the exhaust valve of that cylinder is closed, thereby reducing blow-through of fuel and decreasing emissions. Since the supply of vapour is controlled in this manner, the blow-through of the vapour is prevented so that the vapour is actually used as fuel in the engine, thereby increasing power and decreasing unwanted emissions which would otherwise be created if the vapour simply blows through the engine or is not correctly combusted in the engine due to the timing of the delivery of the vapour into the cylinder.

Preferably the system includes a controller for supplying injection pulses to the liquid injector and injection pulses to the bleed injector so that liquid gas in liquid form and liquid gas in vapour form is supplied only when the inlet valve of the cylinder is open and the exhaust valve of the cylinder is closed.

Preferably the system includes liquid gas supply means for supplying liquid gas for ejection by the injector, the collection means comprises a debubbling chamber in which bubbled or vaporised liquid gas is collected, the injector being located in the chamber so that the collected vapour facilitates cooling of the injector, and a vapour supply line for supplying vapour from the chamber to the bleed injector.

Preferably the bleed injector is sized and the injection pulses applied to the bleed injector are of such a length to control the amount of liquid gas in vapour form which is delivered from the bleed injector to the cylinder of the engine.

Preferably a bleed gas heater is provided for heating the vapour before the vapour is supplied to the bleed injector to ensure that the liquid gas supplied to the bleed

injector is supplied in vapour form for ejection by the bleed injector.

Preferably the bleed gas heater comprises a heater housing for receiving heated fluid, and a bleed line passing through the heater housing for delivering the vapour to the bleed injector.

The heated fluid may comprise engine cooling water. However, other heated fluid could be used, such as exhaust gases.

In the preferred embodiment of the invention the controller comprises the engine control unit of the engine which produces injection pulses for delivery to both the liquid injector and the bleed injector in accordance with engine operating conditions.

The pulse supplied to the bleed injector may, depending on the size of the injector, be the same width as the pulse supplied to the liquid injector, or could be a different width depending on the size of the bleed injector.

Preferably the collecting means comprises cooling means for cooling the liquid injector to prevent bubbling or vaporisation of the liquid gas when in the injector.

Preferably the cooling means includes a housing in which the injector is supported, an inlet in the housing for receiving bubbled liquid gas, and for enabling the bubbled liquid gas to surround the injector in the housing to cool the injector to thereby maintain the liquid gas in the injector in a liquid state, outlet means from the housing for supplying vapour from the housing to the bleed injector.

Preferably the bleed gas heater is arranged between the

outlet means from the housing and the bleed injector.

Preferably the housing includes a pressure regulator for regulating the pressure of the vapour in the housing.

Preferably the pressure regulator comprises a diaphragm, a valve element supported by the diaphragm for closing the inlet, and biasing means for biasing the diaphragm and the valve element towards a closed position, so that when pressure builds up within the housing, the diaphragm is forced against the bias of the biasing means to move the valve element into a closed position, and when pressure reduces in the housing, the biasing means biases the diaphragm to move the valve element to open the inlet.

## Brief Description of the Drawings

A preferred embodiment will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of the preferred embodiment of the invention;

Figure 2 is a detailed view of the preferred embodiment of the invention; and

Figure 3 is a top cross-sectional view showing four injection devices correctly aligned with the inlet ports of the cylinder head and attached to the inlet manifold according to the preferred embodiment of the invention.

## Description of the Preferred Embodiment

With reference to Figure 1 liquid petroleum gas tank 12 supplies liquid petroleum gas via tank lock 14 to service line 16 and onto inline filter 4, the filtered liquid petroleum gas is then conveyed through service line 37 to distribution block 38. From the distribution block 38 the liquefied petroleum gas liquid flows through insulated delivery lines 39 to injector housings 3 (shown in more detail in Figures 2 and 3).

With reference to Figure 2 the liquefied petroleum gas from lines 39 enter respective weir T pieces 8 of each housing 3. The liquefied petroleum gas flows upwards towards stop valve 9 which is controlled by stop valve solenoid 5. Stop valve solenoid 5 is open when energised by ECU 70 on circuit line 127.

When stop valve 9 is open liquefied petroleum gas liquid and vapour bubbles flow through stop valve 9 with the liquid dropping via gravity to injector inlet 201 and the bubbles rise to converter inlet 11.

As is apparent from Figure 2, the injector housing 3 supports the injector 20 and also acts to draw away the bubbles from the injector inlet 201. The injector housing 3 also provides cooling of the injector 20 so as to maintain the fuel in the injector 20 in the liquid state and thereby prevents the fuel from converting into a boiling or bubble state while in the injector 20.

With liquid at injector inlet 201 and a pulse width supplied from ECU 70 to injector 20 the liquid liquefied petroleum gas travels through the injector 20 and is ejected into manifold 32 (see Figure 3), with the spray directed towards inlet port 29 (see Figure 3). The injection of the liquefied petroleum gas is timed by the ECU 70 such that the pulse occurs after the closing of exhaust valve 133 (see Figure 3) and before the closing of the inlet valve 132 (see Figure 3), such that the downward action of piston 131 (see Figure 3) can draw into engine E, all of the liquefied petroleum gas ejected with no blow-by passed exhaust valve 33.

As the liquefied petroleum gas drops over weir T piece 8 for supply of liquefied petroleum gas to injector inlet 201 any vapour bubbles present or formed rise to converter

inlet 11 for pressure reduction in chamber 203 within the housing 3. The housing 3 has a cap portion 203a which is closed by a diaphragm 202. The diaphragm 202 forms one wall of the chamber 203 and the diaphragm 202 is biased inwardly of the chamber 203 by a spring 205. The diaphragm 202 carries a lever 206 which connects to a flat valve 207 which seals the inlet 11, dependent upon the pressure in the chamber 203. As is apparent from Figure 2, the injector 20 is mounted in the chamber 203 and has an inlet 201 supported on a flat 251 and its mid-portion 20a sealed in wall structure 252 and 253 of the chamber 203. The outlet end of the injector 20 is sealed in bore 256 in the chamber 3 which is exposed to the inlet manifold 32 of the engine E.

The liquefied gas supplied through the weir T piece 8 to the inlet 11 is at a significantly higher pressure than the interior of the chamber 203, which pushes the valve 207 open against the diaphragm 202 and biases the spring 205, so that bubbles and vapour which occur in the liquid gas supplied to the inlet 201 will rise and flow into the inlet 11 and into the chamber 203. The reduced pressure within the chamber 203 allows the bubbles to collapse and with any liquid which enters the chamber 203, to turn to vapour thereby cooling the injector 20 which is exposed to the chamber 203. This cooling of the injector 20 ensures that the liquid petroleum gas which enters the inlet 201 is maintained in a liquid state because of the cold state of the injector 20, and does not convert to vapour in the injector 20, which would impair operation of the injector 20 and prevent proper ejection of fuel from the injector 20. Should the pressure in the chamber 203 rise to a pressure above the liquid petroleum gas at the inlet 11, the diaphragm 202 is pushed upwardly in Figure 2 against the bias of the spring 205, which causes the lever 206 to close the flat valve 207 against the inlet to prevent further entry of bubbles and vapour into the housing 203

until the pressure in the housing 203 has decreased by egress of liquid petroleum gas from the housing 203 via outlet conduit 209. Thus, the reduced pressure vapour and liquid in chamber 203 has a cooling effect on the housing 3 and injector 20.

The liquefied gas in the housing 203, which can be in a vapour or liquid state, leaves the housing 203 through conduit 240. The conduit 240 passes through a bleed gas heater 250. The bleed gas heater 250 has an inlet 251 and an outlet 252 which can be connected in an engine cooling water conduit so that engine cooling water which is at a temperature of about 70°C passes through the heater 250 to supply heat to the heater 250 and, in particular, heat to the part of the conduit 240 which is inside the heater 250. Thus, any liquid gas which passes through the conduit 240 is heated and therefore converts to a vapour state if not already in a vapour state. The conduit 240 is connected to a bleed injector 260 which is designed to eject gas rather than liquid, and the injector 260 injects vapour into the inlet manifold 32, as is shown in Figure 2. The bleed injector 260 is controlled by the ECU 70 via pulses received on line 253. The pulses on the line 253, like the pulses on line 86, are timed such that the injector 260 is actuated when the inlet valve 132 is open and the exhaust valve 133 is closed, so that the liquid petroleum gas in vapour state is supplied to the engine E together with the liquid ejected from the injector 20. Thus, the supply of the vapour is controlled in the same manner as the liquid supply and therefore blow-through of vapour through the engine is prevented or at least greatly reduced. The injectors 260 are sized and the pulses supplied on line 251 of such a length that the desired amount of gas is injected into the engine such that emissions are not adversely affected and, at the same time, the cooling effect provided by the passage of liquid gas through the inlet 11, the housing 203 and the conduit

240 does not adversely affect the cooling of the injector 20.

The bleed gas heater 250 ensures that no liquid gas in the liquid state reaches the bleed injector 260, as this would alter the mixture due to the fuel density difference between liquid and gaseous liquid petroleum gas.

The heat supplied by the bleed gas heater 250 is preferably sufficient to ensure that the temperature is well above the liquid petroleum gas vaporisation point and relatively stable.

Figures 2 and 3 also show diesel injector 171 for supplying diesel fuel to the cylinder of the engine E concurrently with the supply of liquid petroleum gas via the injector 20 and the injector 260. Thus, by supplying fuel in the form of liquid petroleum gas from the injectors 20 and 260, the amount of diesel fuel which is required can be reduced, thereby increasing fuel economy compared to situations which would occur when only diesel fuel is supplied via the diesel injector 171. Furtherstill, by ensuring that the liquid gas which is bubbled off in the housing 203 and used to cool the injector 20 is again delivered to the engine in the form of vapour during the cycle of the engine when the exhaust valve 133 is closed and the inlet valve 132 is open, ensures that that fuel is efficiently used thereby increasing power, which means that not so much throttle pressure is required, thereby further reducing fuel. The fact that the fuel is supplied in this manner also prevents blow-through, which would not only waste the fuel, but also may well increase emissions to an undesirable level.

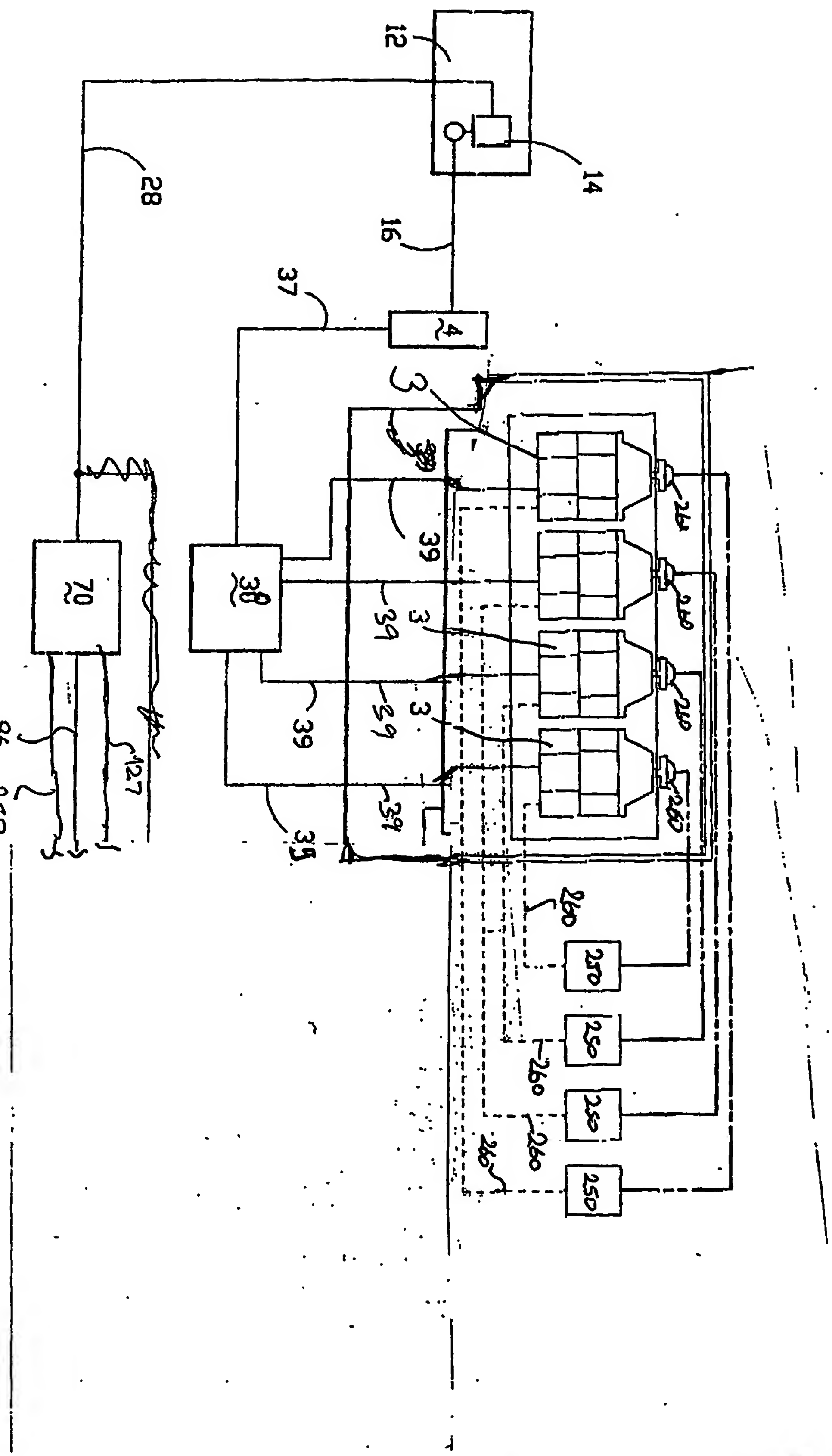


FIGURE ~~2~~ 1

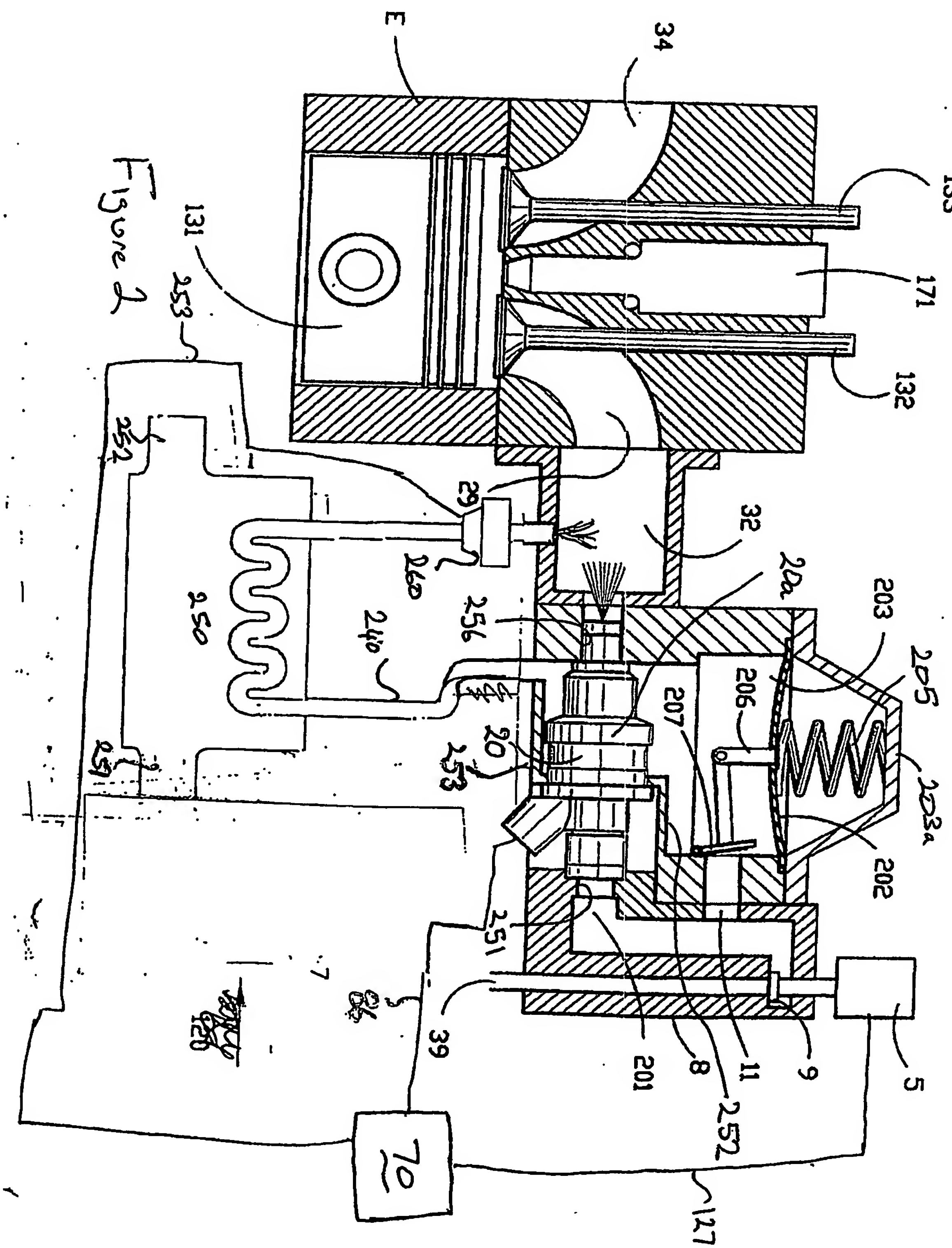

Figure 2

BEST AVAILABLE COPY

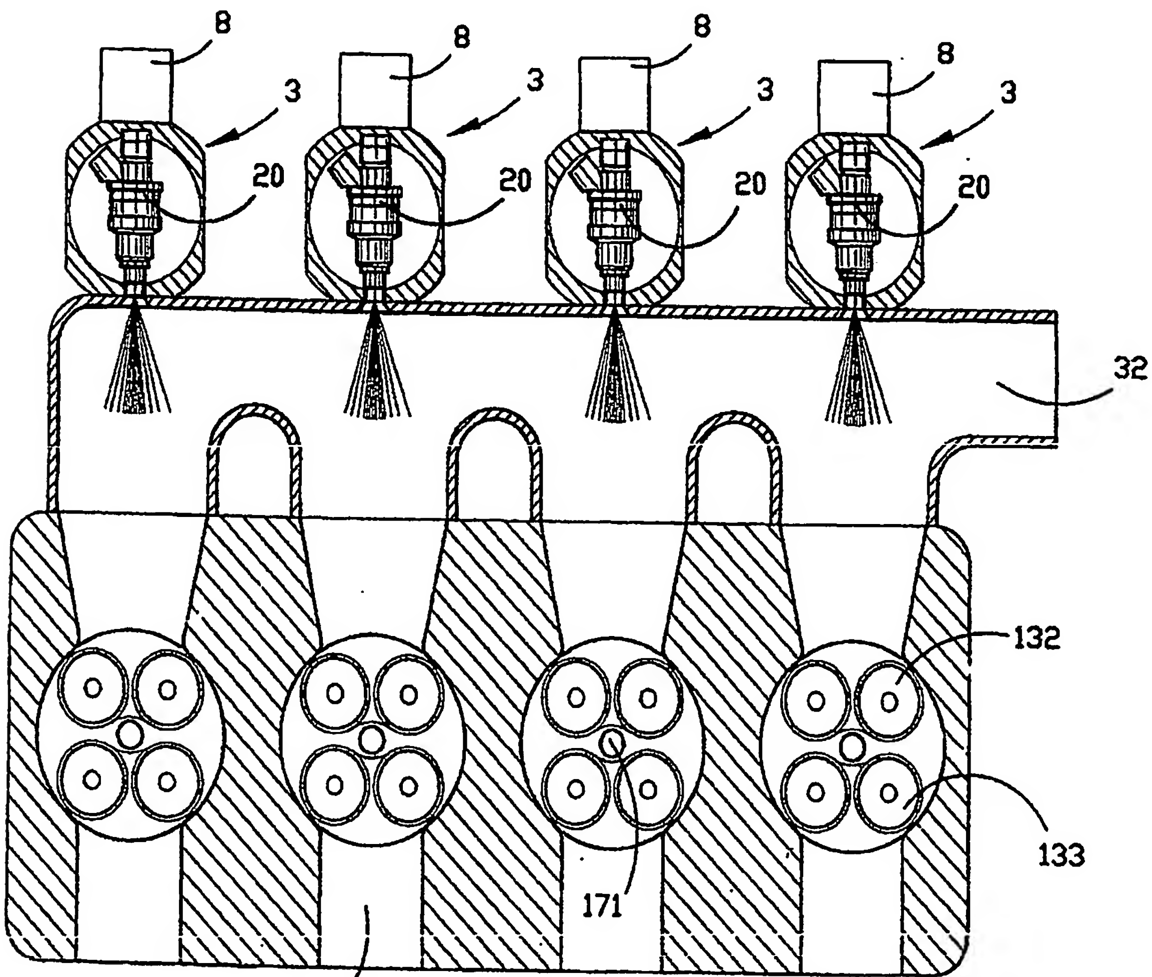


FIGURE ~~6~~3